THE THORACIC SCLERITES OF THE GRASSHOPPER DISSOSTEIRA CAROLINA*

By G. C. Crampton, Ph. D.

There is perhaps no insect which is studied more frequently than the grasshopper, since the drawing of its structural details has served as an introduction to entomology for "generations" of students; yet the parts of its thorax have been surprisingly misinterpreted in practically all text-books and other publications in which it has been described.

Since the incorrect figures and descriptions of the grasshopper's anatomy have been so widely copied in various text-books, (the figures by Packard, 1898, having received the widest acceptance) and other publications, it has seemed advisable to make a further study of the structural details of this insect, with a view to determining what interpretation of the parts is the correct one. For this purpose, the thoracic structures of *Dissosteira carolina*, L., have been selected to illustrate the points to be considered in the following discussion, since this insect is as little modified as any of our common grasshoppers, and is among the largest (and hence the most easily examined) of the forms whose wide distribution makes them available to everyone for study.

In order to avoid the distortion due to the shrinking of dried material, only such specimens as have been preserved in alcohol, or similar preserving fluids, have been used, and in examining them, it has proved more satisfactory to keep the specimens immersed in a liquid medium (alcohol or water) and to illuminate the field of the binocular (which is the most satisfactory microscope for dissection work) by means of a nitrogen-bulb lamp provided with a condenser.

PROTHORAX.

The prothorax is the only thoracic segment which has remained freely mobile, the meso- and metathorax being rather closely united, although the line of demarcation between them

* This paper is one of a series of contributions from the Entomological Laboratory of the Massachusetts Agricultural College, dealing with the anatomy of the grasshopper *Dissosteira carolina* L.

is clearly evident. The grasshopper group thus differs from the crickets and katydids, in which the union of the mesothorax and metathorax is much less close, especially in the sternal region.

The Neck Region.

In front of the prothorax, of which it is a part, is a membranous neck region (Plate XXXII, Fig. 1, "vc"), called the *eucervix* or *veracervix*, by means of which the head is attached to the prothorax; and the membranous character of its integument permits a greater freedom of movement to the head. Since this membranous region might offer a more vulnerable point of attack than the more heavily chitinized segments, it is protected by the forward-projecting, anterior margin of the pronotum, into which the head fits, as in a collar.

Embedded in the more membranous walls of the neck region are several small plates called *jugular sclerites*, *cervical sclerites*, or *cervicalia*, which serve to strengthen the walls of the neck and to furnish points of articulation for the head. Some of them were also formed as points of attachment for certain muscles, since they offer a firmer support for muscle attachment than the more yielding membranous walls of the neck region. These sclerites are homologous with the intersegmental sclerites occurring between the different thoracic segments in certain lower insects, and therefore are not to be interpreted as representing the labial segment, or the remains of a rudimentary segment between the head and prothorax (see Crampton, 1917). In the grasshoppers only the *lateral* and *ventral cervical* sclerites are preserved. The anteriormost lateral cervical sclerite (Figs. 2 and 1, "lc") supports the head. The ventral one, Fig. 2, "ps" is homologous with the so-called *presternum* of lower insects.

The Pronotum.

The *pronotum* is a large saddle-shaped or "sunbonnet-shaped" structure which extends over the greater portion of the dorsal and lateral regions of the prothorax, and projects backward over the anterior portion of the segment behind it. The projecting posterior region of the pronotum is called the "hind *process of the pronotum*" by systematists (Text figure 2, "x"). The two postero-lateral margins of the pronotum form an angle

(in which the letters "x" are contained in Text figure 2). Whether the angle containing the two letters "x" (Text figure 2) is a right angle, or an acute angle, is a feature used in classification. If the sides of the posterior region of the pronotum instead of making an angle, extend approximately straight across, the pronotum is spoken of as *truncate posteriorly*. Similarly, if the anterior margin is approximately straight, it is spoken of as *truncate anteriorly*. Whether the surface of the pronotum is *smooth, granulated* (powdery appearing), *wrinkled, rugose* or roughened with numerous tubercles, are other features of value in classification.

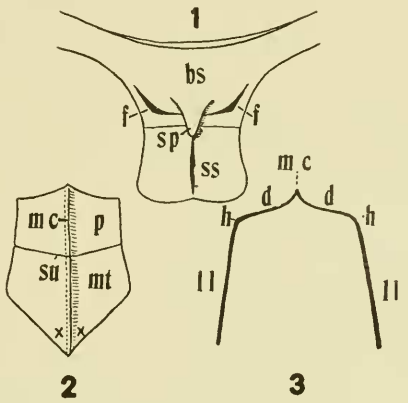

Fig. 1. Ventral view of prosternum of *Rhomalea*.
Fig. 2. Dorsal view of upper portion of pronotum of *Dissosteira*.
Fig. 3. Vertical transverse section through wall of pronotum of *Dissosteira*.

In the grasshopper *Dissosteira*, the pronotum is divided by a *notch* "n" (Fig. 1) and an impressed line "su" extending downward from it, into a *front* and *hind lobe*. The dorsal ridge "mc" (Fig. 1 and Text Figs. 1 and 2) extending longitudinally along the median line of the pronotum is called the *median carina*, and in *Dissosteira* it is broken by a single notch "n" (Fig. 1), while in other grasshoppers there may be two such notches. The median carina "mc" of Fig. 1 is high and arched on the hind lobe of the pronotum of *Dissosteira*, but in other grasshoppers it may be nearly obsolete on the hind lobe. This, and other features, such as whether the median carina is irregular (as in Dissosteria) or whether it is even in contour, are features used in classification.

A downward-bending of the pronotum along the shoulder-like ridge labeled "h" in Fig. 1 and Text Fig. 3 divides the pronotum into an upper surface or *disc* (*i. e.*, the region bearing the labels "p" and "mt" in Fig. 1, or that designated as "d" in Text Fig. 3) and two *lateral lobes*, one on either side of the body, labeled "ll" in Fig. 1 and Text Fig. 3. The shoulder-like ridge "h" of Fig. 1 and Text Fig. 3, demarking the disk of the pronotum from the lateral lobe "ll," is called the *lateral carina*, or better, the *humeral carina*, (since the term lateral carina is also applied to certain ridges of the head region). A lack of ability in shading, has made it difficult to show that the regions labeled "p" and "mt" in Fig. 1, represent a dorsal disc, while the sides, labeled, "ll" are bent downward at an angle with it, and thereby produce the shoulder-like ridge "h." Text Fig. 3, however, represents a vertical cross-section of the pronotum, in which each half of the disc labeled "d," corresponds to the regions designated as "p" and "mt" in Fig. 1. The other labelings are the same in both Text Fig. 3 and Fig. 1, so that by comparing the vertical cross section of the pronotum shown in Text Fig. 3, with the view of the pronotum shown in Fig. 1, the same parts may be readily identified in each.

As was mentioned above, the two lateral or humeral carinæ (Text Fig. 3, "h," and Fig. 1, "h") divide the pronotum into an upper disc and two lateral lobes. The notch "n" and the impressed line "su" extending downward from it (Fig. 1) divide the disc of the pronotum into an anterior region called the "*prozona*" and a posterior one called the "*metazona*" (Fig. 1, "p" and "mt"). It would be preferable to refer to these as the *prezona* and *postzona*, however, since the prefix "meta" is reserved for structures belonging to the meta-thorax alone. The fore and hind margins of the disc of the pronotum may be *truncate*, *rounded*, *angled*, *notched*, etc., and its surface may be smooth, wrinkled, etc., these features being used in classification.

Three approximately vertical sutures or impressed lines called *sulci* (Fig. 1, "su") divide the pronotum into *intralobes* or areas which, beginning with the anteriormost, have been incorrectly designated as the "prescutum," "scutum," "scutellum" and "postscutellum," although they are purely secondary structures having no connection with the four typical subdivisions of the notal region of the wing-bearing segments; and in some grasshoppers there are more than four of these "intralobes."

The Propleuron.

Contrary to the statement that the pronotum has "crowded out" the pleural region of the prothorax (Snodgrass, 1909, pp. 534, 555 and 556), the lateral portions of the pronotum "ll" of Fig. 1 have merely grown down *over* the pleural region which lies beneath the overlapping pronotum, the surfaces of the two regions being closely applied to each other. If one of the larger grasshoppers such as *Rhomalea* be boiled in caustic potash to soften the sclerites, it will be found very easy to separate the pleural sclerites from the overlapping pronotum by inserting a knife blade between the two, and gently forcing them apart. It will then be seen that the *episternum* and *epimerum* (Fig. 2, "es_1" and "em_1") are the principal sclerites of the pleural region, as in the other segments, and that both extend far upward under the overlying pronotum. The lower portion of the episternum and epimerum project below the lower margin of the pronotum in *Dissosteira* (Fig. 2, "es_1" and "em_1"), and if a specimen be boiled in caustic potash, the pleuron can be separated from the overlying pronotum, in this insect also, but this is much more easily accomplished in the larger forms such as *Rhomalea*. The middle one of the three sulci labeled "su" in Fig. 1, is superimposed upon the pleural suture (separating the episternal from the epimeral region) of the prothoracic pleural region which is overlapped by the sides of the pronotum, and, since the surfaces of the pleural region and the pronotum are so closely applied together, it is possible that the presence of the pleural suture is responsible for the formation of the middle sulcus "su" which is directly over it and coincides with it exactly. The posterior suclus "su" is closely associated with the margin of the inflexed portion of the posterior region of the pronotum which is folded in under the remainder of the pronotum, and the surface of the fold is closely applied to the surface of the pronotum. It is possible that the attachment of this margin on the inner surface of the pronotum has given rise to the posterior sulcus "su," and it is thus clearly evident that the sulci "su" of Fig. 1 owe their origin to mechanical causes, rather than to the assumed fact of their representing the four tergal subdivisions of the notum of a wing-bearing segment. Since the pleural region is present, although closely applied to the inner surface of the pronotum

which overlaps it, it thus is incorrect to state that the pronotum has crowded out the propleural region and has assumed its functions.

At the base of the leg is a small articulatory plate "tn" of Figs. 1 and 2. This represents a portion of the *trochantin*, which is much reduced in the Orthoptera.

The Leg.

Only the basal segments of the leg are shown in the accompanying figures, the femur being shortened in each case. As shown in Fig. 2, the prothoracic *coxa*, "cx_1," is divided into several subdivisions, but these have no especial significance. One of these subdivisions bears a *coxal spine* "cs." The coxa is broader than long. The *trochanter* "tr", is small and is quite closely united with the femur.

The Prosternum.

The pleural region of the thorax is connected with the prosternal region by a *pre-coxal bridge* extending in front of the sclerite "tn" (Fig. 2). This pre-coxal bridge is largely made up of a lateral wing of the sternal region, although a small portion of the pleural region is also involved in its make-up.

The anteriormost sclerite of the prosternal region is the small plate "ps" (Fig. 2), which is homologous with the so-called *presternum* of lower insects. Immediately back of the presternum "ps" is a narrow anterior marginal region "pr_1," homologous with a similar anterior marginal region "pr_2" in the mesosternal region. The term *prepectus* has been very appropriately applied to this region in the Hymenoptera by Snodgrass, 1910, although Snodgrass does not think that the sclerite of the Hymenoptera is homolgous with this sclerite in the Orthoptera. Just behind the region "pr" is the *basisternum* "bs_1," whose lateral wings form the precoxal bridges connecting it with the pleural region on either side. In some grasshoppers, this region (the basisternum) bears a prominent spine, the *prosternal spine* (Text Fig. 1, "sp") projecting backward between the front coxæ. The presence or absence of this spine is a feature used in classification. Behind the region "bs_1" (Fig. 2) is an area largely composed of the *spinasternum*, or fourth chief sternal subdivision which has united with the third to form a region sometimes called the *sternellum*. In this

region are situated the two *furcal pits* "f," and the median *spinal pit* "ss_1." The furcal pits "f" are the outward indications of a pair of invaginations or hollow "in-pushings" of the integument serving as structures for muscle attachment. These paired invaginations are called *apophyses*, and when their basal portions unite, while their distal portions remain free to form the two arms of a "Y," the structure is called the *furca* or forked internal structure for muscle attachment. The spinal pit "ss" is the outward manifestation of an internal unpaired median process called the *spina*, which also serves as a point for muscle attachment.

MESOTHORAX.

Despite the fact that the fore wings are reduced to form the so-called *tegmina* which are not as important as the hind wings for flight, and despite the greater development of the hind legs for leaping, and the consequent greater development of the muscles of the metathorax, the mesothorax is subequal to the metathorax in size, being but slightly smaller than the latter.

The Mesonotum.

In the anterior region of the mesonotum is a narrow marginal region "pt_2" (Fig. 3) known as the *pretergite*. In some insects it bears an internal transverse fold called the *phragma*, to which are attached certain dorsal longitudinal muscles serving to arch the notal region in the movements of flight. Immediately behind the region "pt" is an area "psc_2" corresponding to the *prescutum* of other insects, but the prescutum is not demarked from the remainder of the tergal plate in the grasshopper under consideration. The greater portion of the tergal plate is composed of the *scutum* "sc_2," although its limits are not clearly defined in the notum of *Dissosteira*. The region labeled "sl_2" is the *scutellum*, and the area on either side of it is known as the *parascutellum* or *juxtascutellum*, "js_2." The posterior marginal area "po" is the *postergite*, which is a fold-like region projecting backward over the front portion of the segment behind it for a considerable distance in lower insects such as the Mantids, Termites, etc. With the region labeled "js_2," the fold "po" is sometimes incorrectly referred to as the "postscutellum," but the true mesothoracic *postscutellum* is greatly reduced, and projects vertically downward below the

fold which overlaps it, and the postscutellum also bears a *phragma* or internal transverse process for the attachment of the longitudinal muscles arching the notum in the movements of flight.

Along the sides of the *notum*, or tergal region of the segment, are several projections, some of which are involved in the movements of flight. The anterior projection "pa_2" or *prealare*, sometimes forms a complete pre-alar bridge extending in front of the wing from the tergal region to the pleural region, and in some insects it extends down to, or slightly beyond, the pleural plate "ba" of Fig. 3, (*i. e.*, the anterior one of the two plates labeled "ba_2" in Fig. 1). The projecting region "sur_2" (Fig. 3) or *suralare* is frequently demarked by a complete suture, and it serves as an anterior pivot for the wing, in the movements of flight. Certain of the other projections also serve as pivots for the wing in the movements of flight, but are of no great morphological importance.

The Wing-Ossicles.

At the bases of the wing veins are several small articulatory plates called *alar ossicles*, which assist in the articulation of the wings to the tergal region. There are also some small plates below the wing near its attachment to the body, and these are also included under the designation *alar* or *wing ossicles*. The alar ossicles by means of which the wing articulates with the tergal region or notum, are called *pteralia*.

A small plate called the *tegula* "tg" (Fig. 3) occurs near the anterior margin of the wing, at its base, and might be included with the alar ossicles. The principal alar ossicle, however, is the *notopterale* "np_2," which seems to be a detached portion of the tergal region which doubtless originally projected from its lateral margin somewhat after the fashion of the sclerite "sur." In its typical form, this ossicle bears an anterior neck-like narrow region articulating with the base of the vein called the subcosta in Comstock's terminology. Beside the ossicle "np" is a more or less distinct ossicle "m," which is formed at the bases of certain of the wing veins. The radius, media and cubitus of Comstock's terminology may extend to it, although a chitinized area may intervene between it and the bases of certain of these veins. The sclerite "m" has been termed the *medipterale*, or the middle one of the pteralia. The ossicle "b"

or *basanale* is situated at the base of the anal veins, and articulates with a posterior process of the notum which may become detached to form an intermediate plate "a" called the *adanal ossicle.*

The Mesopleuron.

Beneath the wing, at its base, are several alar ossicles which are apparently of a pleural origin, or were formed in the region largely belonging to the pleuron. These have been called the *alaria,* in contradistinction to the pteralia which are tergal ossicles. The two anteriormost of these ossicles "ba_2," called the *basalar ossicles,* are situated at the base of the wing, immediately in front of the dorsal neck-like prolongation of the pleural region serving as a ventral pivot for the wing in the movements of flight. Immediately above this pivot, is the *intralare* "ia_2," and just behind it is the *subalar* ossicle "sa_2."

The greater part of the mesopleural region is composed of the *epimerum* "em_2" and the *episternum* "es_2," which are separated by the *pleural suture* extending in an approximately vertical line from the wing base to the coxal region. Extending along the anterior margin of the region "es_2" is a narrow sclerite "pr_2" called the *prepectus,* and in the upper portion of the episternal region "es_2" a small area labeled "ae" is marked off by a faint suture. Ventral to the episternum and epimerum a *pericoxal* sclerite "pc" extends around the base of the coxa, and encloses the small sclerite "tn," which is all that remains of the much reduced *trochantin.*

In the membranous "intersegmental region" between the prothorax and mesothorax is the first thoracic spiracle "s." This spiracle has been attributed to the prothorax, but from the standpoint of embryology, it is mesothoracic, since it has its embryonic origin in the anterior region of the mesothorax and later migrates into the "intersegmental" region (which is also largely mesothoracic).

The Leg.

As in most Orthoptera, the bases of the legs are widely separated. The pericoxal sclerite "pc_2" encircling the base of the coxa (Figs. 1 and 2) seems to be peculiar to the grasshopper group, since I have been unable to find it in any of the crickets, mole-crickets, or katydids which I have examined. The pleural

suture between the epimerum "em_2" and episternum "es_2" (Fig. 1) is continued downward into the coxal region "cx_2" as the *coxal suture* which divides the coxa into an anterior region (*veracoxa*) and a posterior region (*meron*) in higher insects. The mesothoracic coxæ are broader than long, and tend to assume a ring-like outline.

The Mesosternum.

The mesosternum is connected with the pleural region by a *pre-coxal bridge* "ls_2" (Figs. 1 and 2) extending in front of the coxa on either side of the sternum. In the crickets and katydids, this region ("ls") forms a distinct plate, the *laterosternite*, but in the grasshoppers, it is fused with the episternal region, although a faint line marks it off from the sternal region ventrally. This region originates as a lateral wing of the sternal region, although its true nature is sometimes masked by its secondary union with the pleural region.

A ventral extension of the *prepectus* "pr_2" (Fig. 1) is continued around into the sternal region (Fig. 2, "pr_2") and up the surface of the other flank, thus making an anterior marginal sclerite bordering the pleural and sternal regions. The large sternal sclerite immediately behind it is the *basisternite* "bs_2," and posterior to this is the narrow transverse region containing the *furcal* and *spinal pits* ("f_2" and "ss_2") which mark the location of the internal *furca* and *spina*, or processes for muscle attachment. This region corresponds to the united third and fourth principal sternal subdivisions (the *furca-* and *spinasternite*) to which the designation "*sternellum*" is sometimes applied in the prothoracic region.

In the posterior region of the mesosternum, a suture extending backward in a broad sweep from each of the furcal pits "f_2" marks off a lobe "l_2" and "l_2" on either side of the sternal region. These two lobes are referred to as the *mesosternal lobes* by systematists, while the similar lobes "l_3" and "l_3" marked off in the metasternal region are termed the *metasternal lobes*, and the relative width between these mesosternal lobes (measured transversely between the points labeled "x" and "x" in the mesothorax) as compared with the distance between the metasternal lobes (measured transversely between the points labeled "x" and "x" in the metathorax) is a feature used in classification. Thus in the grasshopper shown in Fig. 2, the mesosternal

lobes are only "slightly more distant than the metasternal lobes"; in other words, the distance from "x" to "x" in the mesosternum is subequal to that from "x" to "x" in the metasternum. In the males, however, the mesosternal lobes may be nearly twice as distant as the metasternal lobes. so that this feature holds good only for females.

METATHORAX.

In the crickets, mole-crickets and most katydids, the metathorax is markedly larger than the mesothorax, especially in the tergal region (as is also true of a few other insects, such as the earwigs, beetles, Strepsiptera, etc.) and one would naturally expect the same to be true of the grasshopper group also, since the hind wings and hind legs are much larger than the others and consequently require larger muscles for operating them. The meso- and metathorax are subequal in size, however, in *Dissosteira*, and the two wing-bearing segments are more or less closely united to furnish a firmer support for the wing muscles, since the grasshoppers are better fliers than the crickets and katydids.

The Metanotum.

An anterior region "psc_3" which corresponds to the *prescutum* is indistinctly marked off in the tergal region of the metathorax (Fig. 3), and behind it is the scutum "sc_3" which is of a somewhat indefinite extent. The *parascutellar* regions "js_3" of the metanotum are not strictly homologous with the regions labeled "js_2" in the mesonotum, since they extend over a greater area in the metanotum; but it is inadvisable to attempt to distinguish between the two in the different segments, since they are practically the same in position, etc., in both meso- and metathorax. The metathoracic *scutellum* "sl_3" is not very different from the mesothoracic scutellum "sl_2"; but the *postergite* "po_3" or region behind the scutellum is of greater extent in the metathorax than in the mesothorax ("po"). The mesothoracic postscutellum is greatly reduced, and is overlapped by the region "po," but in the metathorax, the *postscutellum* "psl_3" is large and well.developed, although it is more or less closely united with the first abdominal tergum. Along its posterior margin, it bears an internal transverse ridge or *phragma*, to which certain longitudinal dorsal muscles are

attached (and which serve to arch the tergal region in the movements of flight). The *prealar region* "pa_3" of the metanotum is essentially like that of the mesonotum "pa_2," but the *suralar* process "sur_3" of the metathorax is slightly different from that of the mesothorax "sur_2."

The Wing-Ossicles.

The *tegula* "tg_3" (Fig. 3) is present in the metathorax as well as in the mesothorax of the grasshopper, unlike many other forms in which it is retained in the mesothorax alone. The *median ossicle* "m_3" of the metanotum is not very different from its homolog in the mesonotum; but the *notopterale* "np_3" has lost its slender neck-like prolongation present in the homologous plate "np_2" of the mesonotum; although the small plate just in front of the projection "sur_3" of the metanotum, doubtless represents the remains of this anterior neck-like prolongation of the notopterale. The *basanal* region "b_3" at the base of the anal veins is much larger in the metathorax than in the mesothorax, but the plate "a" of the metanotum is smaller than its homolog in the mesonotum.

The Metapleuron.

The ossicles "ba_3," "ia_3" and "sa" (Fig. 1) of the metathoracic region are essentially like those of the mesothorax. The postscutellum "psl_3" extends downward behind the wing, making a postalar bridge connecting the tergal region with the *epimerum* "em_3," whose shape is somewhat different from that of the mesothoracic epimerum "em_2." The metathoracic *episternum* "es_3" is demarked from the region "ls_3" by a faint line which is absent in the mesothorax, while on the other hand, the faint line demarking the region "ae" which is present in the mesothoracic episternum is lacking in the metathoracic episternal region. The region "ls_3" is largely composed of the *laterosternite*, or lateral wing of the sternal region. Behind it, a narrow *antecoxal region* "ac_3" is marked off in front of the metathoracic coxa "cx_3," and appears to be homologous with a portion of the pericoxal ring "pc_2" extending around the mesothoracic coxa. The metathoracic trochantin is reduced to the small plate "tn" at the base of the coxa. The metathoracic spiracle "s" is actually situated in the intersegmental region, but appears to be located in the posterior portion of the mesothoracic pleuron.

*The Leg.**

The metathoracic coxa "cx_3" is much larger than the coxæ of the other segments due to the greater development of the hind legs for leaping, and tends to become longer than the other coxæ. The trochanter "tr_3" (Fig. 2) is greatly reduced, and is more readily seen from the ventral (or mesal) surface. The femur is greatly thickened for leaping, and is provided with prominent longitudinal ridges on its inner surface.

The Metasternum.

The principal region of the metasternum is the *basisternum* "bs_3" (Fig. 2) which interlocks with the mesosternum in front of it, the narrow anterior region of the metasternum being "dovetailed" between the mesosternal lobes "l_2" and "l_2." The lateral wings of the basisternum largely make up the sclerite "ls_3" forming a pre-coxal bridge on either side of the body, connecting the sternal with the pleural regions. The *antecoxal region* "ac_3" is largely sternal in origin, and, with the sternal sclerite "st," it forms an incomplete ring extending around the base of the coxa anteriorly, so that these two sclerites may represent a portion of the ring "pc" which completely encircles the base of the mesothoracic coxa. The *furcal pits* "f_3" are retained in the metasternum, but the spinal pit "ss_2" of the mesosternal region has disappeared in the metasternum. The *metasternal lobes* "l_3" and "l_3" are somewhat smaller than the mesosternal lobes. In certain grasshoppers the transverse distance between the two points "x" and "x" of the metasternum is only half the distance between the points "x" and "x" of the mesothorax (*i. e.*, the mesosternal lobes are "twice as distant" as the metasternal lobes)—a feature frequently used in classification. The greater part of the region between the metasternal lobes "l_3" and "l_3" is thought to be an anterior "neck" of the first abdominal sternum which has become wedged in between the metasternal lobes, although it is rather difficult to understand how such a dovetailing process

* Since the coxa of the metathorax is called the metacoxa, the tibia of this segment is called the metatibia, etc., the tarsus of the metathorax should be designated as the metatarsus; but since the designation metatarsus is sometimes incorrectly applied to the basal tarsal segment of the prothoracic or mesothoracic regions, it is preferable to designate the basal segment of the tarsus as the praetarsus, or basitarsus, in all cases, if we are to avoid ambiguity.

could be brought about. At any rate, the mesosternum *appears* to be dovetailed into the metasternum and the first abdominal sternum appears to be dovetailed into the metasternum, which is a condition peculiar to the grasshopper group (so far as I am aware). None of the crickets or katydids which I have examined has a mesothoracic ring "pc_2" about the base of the coxa (Figs. 1 and 2), or a metathoracic sclerite like those shown in Fig. 2, "ac_3" and "st," so that these structures, together with the "dovetailed" condition of the sternal regions, may be characteristic of the grasshoppers alone, and serves to further separate them from the crickets and katydids.

OTHER INTERPRETATIONS.

The Tergal Region.

Brooks, 1882, page 247 (also Fig. 130 of "*Acridium*") is apparently responsible for the frequently repeated statement that the pronotum of the grasshopper is divided into four regions homologous with the prescutum, scutum, scutellum, and postscutellum of the other segments of the thorax, and this view has been adopted by Comstock and Kellogg, 1902 (p. 21) and many other writers. The fact that this view cannot be the correct one, however, is demonstrated by the occurrence of five or even six such areas in the pronota of some grasshoppers, as well as by the fact that the four principal tergal subdivisions never occur as transverse bands in the other segments. The line of division between the true scutum and scutellum never lies directly over the pleural suture (as is supposed to be the case in the pronotum), since the true scutellum is usually triangular in outline. Furthermore, the true postscutellum is always formed as a plate distinct from the plate in which the prescutum, scutum, and scutellum are demarked, and, in connection with many other facts such as the nature of the musculature attached to the regions in question, etc., the pronotal subdivisions cannot possibly be interpreted as representing the four typical tergal subdivisions, but evidently owe their origin to mechanical causes as pointed out in the preceding discussion.

Brooks, 1882, (p. 250, and Fig. 133) would interpret the narrow transverse marginal region of the mesonotum ("pt_2" of Fig. 3 of this paper) as the "prescutum," but it is clearly not the entire prescutum, being merely the narrow anterior mar-

ginal region of the prescutum called the pretergite. Brooks (p. 250) apparently interprets the alar ossicle "np_2" as the "patagium" (which is really an erectile lobe on the pronotum of Lepidoptera, having nothing to do with the sclerite "np_2," although Brooks may have had the tegulæ in mind, since the tegulæ are sometimes incorrectly homologized with the sclerite "np_2") and he homologizes the regions "js_2" and "po" (of Fig. 3 of the present paper) with the "postscutellum." (See also Fig. 32 of Melanoplus by Lugger, 1898). The true postscutellum of the mesothorax, however, is situated below the region "po" and bears the characteristic longitudinal dorsal muscles attached to the postscutellum of other insects, so that the representative of a mesothoracic postscutellum is present in grasshoppers, despite Snodgrass' statement to the contrary.

Berlese, 1909. has discussed the tergal region of *Acridium*, but, since I have no specimens of the species which he figures, I am not sure that the regions into which he subdivides the tergum correspond to those here given, especially since Berlese doesn't homologize the sclerites correctly in different insects, and as Snodgrass, 1909 (p. 535) very truly remarks "in order to carry out his scheme, Berlese has in many cases drawn purely arbitrary lines across the notum." Furthermore, Berlese employs the prefixes "pro," "meso," and "meta" for subdivisions of one and the same segment instead of limiting the prefix "pro" to prothoracic structure, "meso" to mesothoracic structures, and "meta" to metathoracic structures. Thus "metatergite" to any one else would mean the tergite of the metathorax, but Berlese applies this term to a subdivision of the pronotum, mesonotum or metanotum indiscriminately, as is also true of his terms "mesotergite" and "protergite." As nearly as I can determine, the tergal subdivisions which he describes in *Acridium* correspond to the following tergal sclerites of the grasshopper here discussed.

In his Fig. 1, Plate IV, Berlese applies the term "acrotergite" to the *anteriormost* tergite "pt_2" of the mesothorax of the grasshopper (Fig. 3 of this paper) while he applies this same term to the *posteriormost* tergite "psl_3" (Fig. 3) in the metathorax of the grasshopper. In the mesonotum, he terms only the region "sur_2" the "protergite," and homologizes it with the entire prescutum "psc_3" in the metathorax. The scutum "sc" and scutellum "sl" comprise his "mesotergite" and the region

which he calls the "metatergite" is apparently the sclerite "js" and "po" together. In his Fig. 274 of the metanotum of *Acridium*, Berlese terms the tegula "tg_3" the "acroptero," and designates the ossicles "np_3" and "m_3" together as the "proptero." The sclerite "a" he terms the "mesoptero," and designates the region "b_3" as one of the "capi delle nervature delle interala."

The Pleural Region.

The lateral cervical sclerites "lc" (Figs. 1 and 2) are interpreted as the episternum and epimerum of the labial segment of the head by Comstock and Kochi 1902 in their Fig. 20 of the lateral neck plates of *Melanoplus* (see also Fig. 26 of Melanoplus by Hosford, 1913); but, in a paper dealing with the nature of the neck sclerites (Crampton, 1917) it was shown that these plates are merely detached portions of the prothorax, and therefore cannot represent the episternum and epimeron of the labial or any other segment.

In his Fig. 7 of the mesopleuron of *Acridium*, Jordan, 1902, calls the region "ae" of Fig. 1 (of this paper) the "parasternum" (a term previously applied to a different region by Heymons and others); but in other instances, Jordan applies the term "parasternum" to the basalar plates "ba." He terms the sclerite "pr_2" (Fig. 1) the "peristernum" in the pleural region, and designates its median ventral portion "pr_2" of Fig. 2, as the "mesoclidium," although it is not homologous with the sclerites which he designates as the "mesoclidium" in his other figures (*e. g.*, his Figs. 17, 19, etc., in which the "mesoclidium" appears to represent the region "ss" of Fig. 2 of this paper). Comstock and Kellogg, 1902, call the region "pr_2" the "sternellum."

Berlese, 1909, designates the basalar plates "ba" (Fig. 1) as the "due meta dell' acrosterno o prefulcro," while he terms the sclerites "ia" the "endoptero," and "sa" the "paraptero." Snodgrass, 1909, also appears to think that these plates at the base of the wing are the "paraptera," since he calls the anterior ones "ba" the "episternal paraptera" and the posterior one "sa" the "epimeral parapteron," but, as was pointed out in a paper dealing with the application of the terms parapteron, hypopteron, etc. (Crampton, 1914b) the designation parapteron is a synonym of tegula alone, and is so used in practically all textbooks of Entomology.

In his Fig. 89 of the locust *Melanoplus*, which has been copied in many textbooks and other publications, Packard, 1898, restricts the term coxa to the anterior region of the coxa ("cx_2" of Fig. 1 of this paper) and terms its posterior portion the "trochantine," in the pro- and mesothorax of the grasshopper, although the true trochantin "tn" (or what is left of it) is present. In the metathorax of his figure of *Melanoplus* Packard interprets the anterior region of the membranous area above the coxa "cx_3" (Fig. 1) as the "coxa" and the posterior region of this membranous area he designates as the "trochantine." The true metathoracic coxa "cx_3," he calls the trochanter.

The Sternal Region.

Jordan, 1902, in his Fig. 7 of *Acridium* terms the ventral portion of the anterior marginal region "pr_2" (Fig. 2 of this paper) the "mesoclidium" in the mesothorax of the grasshopper, and designates the lateral portion of this marginal region as the "peristernum." The term "sternum" is restricted to the portion of the sternum behind the region "pr_2" by Jordan, who applies the term "sternite" to the ventral and entire lateral region of the segment.

Snodgrass, 1909, in his Fig. 70, of the mesopleuron of *Dissosteira*, terms the region "pr_2" (Figs. 1 and 2 of this paper) the "pre-episternum," but the "pre-episternum" of his Fig. 56 of *Melanoplus*, and Fig. 57 of *Hippiscus* is an entirely different sclerite, namely the region "ls_3" of Fig. 1 (of this paper). Snodgrass, 1910, designates a region which for all practical purposes corresponds to the region "pr_2" (Figs. 1 and 2) as the "prepectus" in the Hymenoptera, but he claims that the "pre-episternum" is not present in the Hymenoptera. This is apparently due to the fact that he has applied the term "pre-episternum" to so many different sclerites in his earlier paper; but since the region which he calls the prepectus in the Hymenoptera is located in the same position as the sclerite which he designates as the "pre-episternum" in the grasshoppper *Dissosteira*, and extends into the sternal region in the same way (*i. e.*, sclerite "pr_2" of Fig. 1), it would appear that Snodgrass is mistaken in concluding that the "prepectus" of Hymenoptera is not to all intents and purposes homologous with the sclerite "pr_2" (Figs. 1 and 2) which he terms the "pre-epister-

num" in *Dissosteira*. The term "prepectus" is much preferable to "pre-episternum" however, since "pectus" is the term for the united pleural and sternal regions; and "pre-pectus" is therefore a very appropriate designation for the anterior marginal region of the pleural and sternal regions, so that the designation prepectus has been retained in the present paper rather than the designation "pre-episternum" or the designation "hypopteron" which was originally applied to this region in the Coleoptera by Audouin (see Crampton, 1914b).

Comstock and Kellogg, 1902, (p. 22) have proposed the surprising view that the sclerite "pr_2" of Figs. 1 and 2 (which represents the anterior marginal prepectus of the *mesothorax* is the "sternellum of the *prothorax*," and they would homologize it with the mesothoracic lobes "l_2" and "l_2" of Fig. 2, which they regard as the "widely separated halves of the sternellum of the mesothorax" (p. 24). These in turn, they homologize with the metathoracic sclerites "st" of Fig. 2, which they refer to on page 24 as "the two halves of the sternellum of the metathorax . . . widely separated, each being situated near the base of the leg." If one takes into consideration such "landmarks" as the furcal pits "f" however, it will be seen that it is impossible to homologize the regions "pr_2" or "l_2" with "st" in Fig. 2. Comstock and Kellogg restrict the term "sternum" to the region in front of the lobes.

In his Figs. 197 and 198 of the sternal region of *Acridium*, Berlese 1909 gives some very astonishing interpretation of the sclerites. Thus in the mesothorax, he restricts the term "sterno" (*i. e.*, sternum) to the marginal region "pr_2" (Fig. 2) alone, and designates all the remainder of the mesosternum (*i. e.*, "bs_2" and "l_2" of Fig. 2) as the "sternello" (*i. e.*, sternellum). In the metathorax, however, he calls practically the entire metasternum the "sterno" and designates the first abdominal sternum as the "sternello" of the metathorax. In fact, Berlese's interpretations of many of the sclerites in his figures of the thorax of different insects are so incorrect as to greatly detract from the value of his book as a basis for research, although its monumental size and wide scope have placed it among the most important of the reference works in Entomology.

BIBLIOGRAPHY.

1909. **Berlese.** Gli Insetti.
1902. **Blatchley.** The Orthoptera of Indiana.
1882. **Brooks.** Handbook of Invertebrate Zoology.
1902. **Comstock and Kellogg.** Elements of Insect Anatomy. (Fourth edition).
1902. **Comstock and Kochi.** Skeleton of the Head of Insects.—Amer. Nat. 36, p. 13.
1909. **Crampton.** Thoracic Sclerites of Insects.—Proc. Acad. Nat. Sci., Philadelphia, Jan. 1909, p. 3.
1914a. **Crampton.** Thoracic Sclerites of Winged Insects.—Ent. News, 25, p. 5. See also Zool. Anz. 44, p. 56.
1914b. **Crampton.** On the Misuse of the Terms Parapteron, etc.—Jour. N. Y. Ent. Soc. 22, p. 248.
1915. **Crampton and Hasey.** Basal Segments of the Leg in Insects.—Zool. Jahrb. Anat. 39, p. 1.
1917. **Crampton.** Neck Region of Insects.—Ann. Ent. Soc. America, 10, p. 187.
1907. **Finot.** Sur le Genre Acridium.—Ann. Soc. Ent. France, 76, p. 247.
1898. **Hyatt and Arms.** Insecta.
1899. **Hunter.** Grasshopper anatomy.—Contrib. Ent. Lab. Univ. Kansas.
1902. **Jordan.** Mesosternit der Tagfalter.—Verh. V. Internat. Zool. Congr. Berlin, p. 816.
1898. **Lugger.** Third Rpt. Entomologist Minnesota on Orthoptera of Minnesota.
1898. **Packard.** Textbook of Entomology. (See also Third Rept. U. S. Ent. Commission).
1903. **Snodgrass.** Anatomy of the Carolina Locust Dissosteria.—Wash. State Agr. College.
1909. **Snodgrass.** Thorax of Insects.—Proc. U. S. Nat. Mus. 26, No. 1687.
1910. **Snodgrass.** Thorax of Hymenoptera.—Ibid. Vol. 39. (See also U. S. Bur. Ent. Tch. Ser., No. 18).

EXPLANATION OF PLATE XXXII.

In all Figures the legs have been shortened, and the head has been removed. Only the first abdominal segment shown.

Fig. 1. Lateral view of the neck, thorax and first abdominal segment.
Fig. 2. Ventral view of same.
Fig. 3. Dorsal view of mesonotum, metanotum, and a portion of the first abdominal tergum.

ABBREVIATIONS.

The subscripts 1, 2 or 3, denote that the structure in question belongs to the pro-, meso-, or metathorax respectively. 1 ab denotes the first abdominal segment.

a, Adanale, or adanal ossicle.
ab, Abdominal segment.
ac, Antecoxale, or antecoxal piece.
ae, Anepisternum, or upper region of episternum.
b, Basanale, or basanal ossicle.
ba, Basalar sclerite.s
bs, Basisternum.
cs, Coxal spine.
cx, Coxa.
d, Disc of pronotum.
em, Epimerum.
es, Episternum.
f, Furcal pits.
h, Lateral or humeral carina of pronotum.
ia, Intralare, or intralar ossicle.
js, Parascutellum, or juxtascutellum.
l_2, Mesosternal lobes (lobisternite).
l_3, Metasternal lobes (lobisternite.
lc, Lateral cervicals.
ll, Lateral lobes of pronotum.
ls, Laterosternite, or wing of sternal region.
m, Medipterale, or median ossicle.
mc, Median carina of pronotum.
mt, Postzona, or "metazona" of pronotum.
n, Notch in median carina.
np, Notopterale, or notopteral ossicle.
p, Prezona, or "prozona" of pronotum.
pa, Prealare, or prealar region.
pc, Pericoxale, or pericoxal ring.
po, Postergite.
pr, Prepectus, or hypopteron.
ps, Presternum.
psl, Postscutellum.
pt, Pretergite.
s, Spiracle.
sa, Subalare, or subalar plate.
sc, Scutum.
sl, Scutellum.
sp, Prosternal spine.
ss, Spinal pit.
st, Sternocoxale, or sternocoxal sclerite.
su, Sulci, or pronotal sutures.
sur, Suralare, or suralar region.
tg, Tegula, or parapteron.
tn, Trochantin, or trochantinus.
tr, Trochanter.
vc, Neck region, eucervix, or veracervix.